# The Reduction Potential of Transportation-Derived Carbon Emissions at the University of Toronto Scarborough

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EESC34

April 9, 2020

**Abstract**

As students at the University of Toronto Scarborough (UTSC), commonly known as a commuter campus, we have come to observe both students and faculty exercising methods of transportation to and from campus that make an unnecessarily large contribution to the university's ecological footprint via the carbon emissions of these transportation habits. We undertook this research project in an effort to gain a better understanding of the relationship between a university campus's ecological footprint and their campus users' transportation habits in order to make effective policy changes and infrastructure developments to reduce this ecological footprint. Due to time constraints and the unfortunate occurrence of the COVID-19 pandemic, our original strategy of gaining insight into campus users' transportation habits via online and in-person surveys had to be substituted for the extrapolation of existing data on the campus demographic and a standardized carbon emission amount for the average vehicle to fit the current UTSC demographic and illustrate their contributions to the university's ecological footprint. As a result, it was decided that a 30:70 ratio of drivers to public transit commuters would be used to balance the overall emissions in relation to their distance, and calculations were conducted using this information. For our calculations, we also assumed that the average personal vehicle in Canada emits 212.9 g $CO_2$ per km, and individuals who take the bus, on average, emit 41.4 g $CO_2$ per km, amounts credited to reliable external sources. Following our findings from these calculations, we developed three scenario models to illustrate how UTSC could effectively reduce their emissions, and consequently their ecological footprint. This study hopefully lays the groundwork for future investigation into how transportation contributes to a university's ecological footprint and can be used to inform future policies and development of infrastructure put forth by both the University of Toronto and the city of Toronto in order to reduce their ecological footprints by targeting transportation.

**Keywords:** carbon emissions, commuters, ecological footprint, transportation, scenario models, environmental sustainability, mobility habits

## Introduction

Transportation and travel is a major component of a University's ecological footprint (0.08 - 72.7%) (Pérez-Neira et al., 2020). As a result, in order for Universities to contribute to the highly desirable goal to meet the 2050 net carbon neutral standard, it is within their best interest to promote sustainable transportation habits that will reduce greenhouse gas emissions. The University of Toronto Scarborough Campus, in particular, is a commuter-dominant institution, which makes it the perfect case study for exploring the potential environmental benefits of introducing alternative mobility habits.

The proposed study will examine the current transportation habits of students at the University of Toronto Scarborough Campus. This project draws inspiration from a study conducted by the Department of Economy and Statistics at the University of Leon in Spain (Pérez-Neira et al., 2020). The study examined the University's potential to mitigate the effects of greenhouse gases through a series of optimal scenario models, such as increasing occupancy of cars by 25-50%, increasing travel by bus foot or cycling within 0-4 km range. The results of the study could not be replicated by UTSC due to major differences in geography, climate and relational distance from campus grounds. For example, 94% of the total number of travels occurred within a 6 km range (Pérez-Neira et al., 2020). However, the methods of data acquisition were useful in displaying an ecological baseline prior to applying our own reduction scenarios. The study also provided literature that aided in creating the carbon emissions values for our study. The study utilized a higher percentage of diesel vehicles (in Leon) and a different national fuel economy (Pérez-Neira et al., 2020).

This project will attempt to model the current ecological footprint of the University of Toronto Scarborough Campus. The model will focus on carbon emissions derived from commuting to campus (private vehicles and public transportation). The project will propose three mobility-oriented strategies to reduce the campus's carbon emissions; the inclusion of electric vehicles (25%), mandatory public transit regulations for students within 10 km (driving distance) of UTSC, and improving public transit systems within 30 km of the campus resulting in a 15% overall increase in public transportation-use within this distance.

## Methods

### *Research Design and Procedures*

The study's methodology consisted of two sections; the first attempts to establish an ecological baseline (transportation-derived carbon emissions) from which the carbon mitigation strategies could be tested in the second phase. Determining the ecological baseline required identifying the sample's preferred modes of transportation and the distances travelled. The project's initial method of gathering this data, and also the most accurate way of representing the sample, is an online survey. The survey comprised two segments. The first segment identified the affiliation of the individual to the campus (student, faculty or staff), their year of study (if applicable), and academic program. The second segment pertains to the mode of transportation, one way travel time and distance of the commute. It began by asking the respondents' main mode of transportation to campus. The options presented are walking, car/personal vehicles, carpooling, rideshare services or public transportation. We have also included an additional option where the respondent can list another method of travel not included in the survey. The survey continued to ask the distance (km) and time associated with a one-way trip from the respondents home to campus. For those who selected public transportation, the temporal element would also include waiting/walking time to transit terminals.

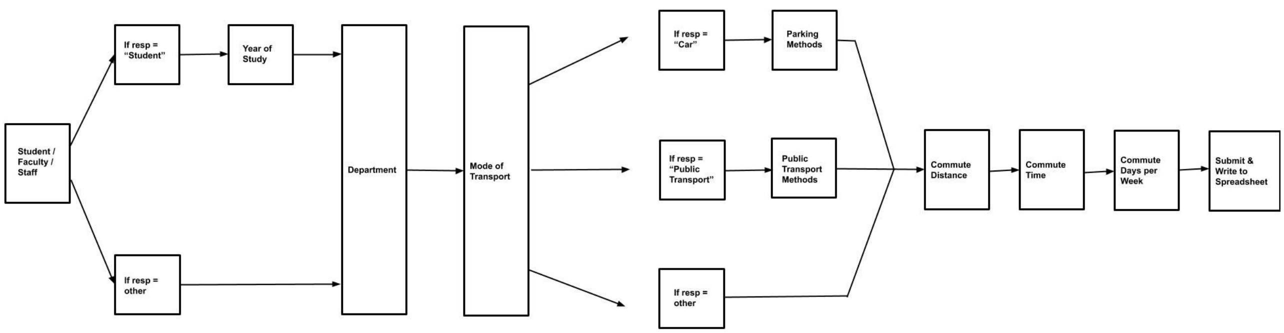


**Fig. 1:** Campus Transportation Survey Logic Tree

*Data Provided*

Due to a combination of both time constraints and the lack of a platform to massively distribute the online survey, our representational data had to be sourced from the campus. The CAO's Office at the University of Toronto Scarborough was kind enough to provide a directory containing the Forward Sortation Area (FSA) codes of students currently enrolled at the University of Toronto Scarborough Campus. Entering the FSA code into Google Maps placed a point at the centre of the region and was able to provide the distance between that point and the campus. This was the longest portion of the methodology as a sample utilized for the project contained the FSA codes of all students within 140 km driving distance of the campus. It was assumed that students living in excess of this distance were not daily commuters and exempt from the study. The distances were then grouped within 10 km ranges and given carbon emission values based on the population within the group and their distance from campus. The carbon equations used for this project are listed below:

The average personal vehicle in Canada emits 212.9 g $CO_2$ per km.

*1 litre of petrol* = 750 g. It is 87 % carbon (625 g)/L.

To combust 1 litre of petrol, it requires 1740 g of Oxygen ($O_2$) = 1740 + 625 = 2392 g (ecoscore.com)

*Average Canadian fuel economy* = 8.9 L/100 km (Canada Energy Regulator)

(2392 g x 8.9 L) / 100 km = 212.9 g $CO_2$/km

Individuals who take the bus, on average, emit 41.4 g $CO_2$ per km.

*1 litre of diesel* = 835 g. It is 86.3 % carbon (720 g)/L.

To combust 1 litre of diesel, it requires 1920 g of Oxygen ($O_2$) = 1920 + 720 = 2640 g (ecoscore.com)

Fuel economy of a 50 passenger bus (Urban) = 78.4 L/100 km (Larsen et al., 2011)

(2640g x 78.4 L) / 100 km = 2,069.76 g $CO_2$/km

Within a 50 passenger bus, this results in approximately 41.395 or 41.4 g $CO_2$/km.

*Study Assumptions*

For this study, it is assumed that 30% of students arrive on campus by driving or being driven in a vehicle. The relationship is represented as a 1:1 ratio of vehicle to passenger commuting. It is assumed the remaining 70% of the sample commute to campus via public transportation. According to a survey conducted by Student Move TO in 2015, across Toronto's four Universities (UofT, Ryerson, York, and OCAD), approximately 59% of UTSC students take local transit, an additional 5% take regional transit for a total of 65% , 11% drive personal vehicles, while another 11% arrive through some form of rideshare. The remaining respondents walked or cycled to campus. (StudentMoveTO, 2015).

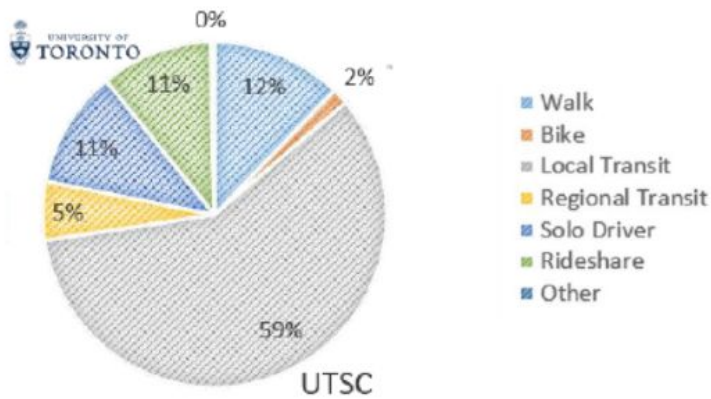


**Fig. 2:** Pie chart by *StudentMoveTO s*howing the proportion of various means of travelling to campus.

It was decided that a 30:70 ratio of drivers to public transit commuters would be used to balance the overall emissions in relation to their distance. Students who live further from campus would invest in or borrow a family vehicle to avoid excess travel duration and overall inconvenience. This would result in a greater proportion of students who live further away driving/being driven to UTSC and in turn yield greater carbon emissions. Unfortunately, without a survey to verify this relationship, we had to make our own assumptions. Therefore the 30:70 ratio was chosen rationally to reflect greater carbon emissions from personal vehicles.

**Results and Discussion**

Of the 11,595 students covered by the analysis, there were found to be approximately ~3478 drivers: all of whom lived from fewer than 10 to 140 kilometers from campus. These drivers are responsible for a total of 13.3 metric tonnes of $CO_2$, a disproportionately large amount of which came from drivers living from 10 to 20 kilometers away from campus (Fig. 3). Relative to drivers who lived 0 to 10 kilometers from campus, drivers who lived 10 to 20 kilometers away contributed 376% greater emissions despite there only being 60% more per-group drivers (see Fig. 3). Commuter-based emission data, while being overall lower, followed a similar distribution. In fact, despite accounting for more than twice the amount of per-capita transport, commuters were responsible for 45% fewer emissions than drivers (only 6.1 metric tonnes $CO_2$ vs 13.3) (see Fig. 4). Despite the ostensive benefits of public transit as a form of commuting, factors such as availability and efficiency of routes must also be taken into account. Many drivers likely find owning a private vehicle to be much more convenient than taking public transit, as they are able to commute at their own leisure while also being able to take more direct routes to their destination. A primary disadvantage of public transit, in addition to a lack of longer distance options, is the relative inefficiency of routes travelled. In order to service a wide array of commuters public transit routes must route through various urban and suburban centers: often following rather complex, indirect routes to an ultimate destination. In order to maximize the efficiency of public transit routes one must first address the problem of maximizing the efficiency of routes traveled. Modifications to infrastructure aside, this research also assessed the efficacy of 3 different scenarios regarding modification to driver and transit commuter habits: making 25% of driven vehicles electric or otherwise carbon-neutral, mandating public transport for all students who live within 10 kilometers of campus, and increasing overall public transit use by 15% (up to a total of 85%) for students within 30 kilometers of campus respectively. With scenario one it was, not surprisingly, found that total emissions dropped by 25% from 13.3 to 9.9 tonnes of $CO_2$ (see Fig. 5).

Given current plans for the UTSC campus to expand its available parking, it may also be possible that electric-vehicle exclusive parking options may be expanded as well: further incentivizing the adoption of electric or green vehicles. Scenario two had more modest results; it was found that mandating public transport within 10 kilometers of campus only decreased driver emissions by approximately 8%, with public transit emissions being increased by 3.5% (see Fig. 6). It should also be noted that this scenario presents an ethical dilemma where one would have to forcibly compel commuting behavior of individuals: making it a very unrealistic scenario. Scenario three had the most promising results, with driver emissions seeing a sharp decline by a near perfect 50% to only 6.6 tonnes of $CO_2$ (see Fig. 7). The converse of this, however, being that public transport related emissions rose by 21% up to 7.4 tonnes of $CO_2$ (see Fig. 7). With consideration to the greater per-capita efficiency of public transport and lower overall emissions, however, this scenario would appear to have the most significant results. By fulfilling the aforementioned needs to increase the efficiency of public transport, scenario three has the greatest odds of being enacted and seeing success.

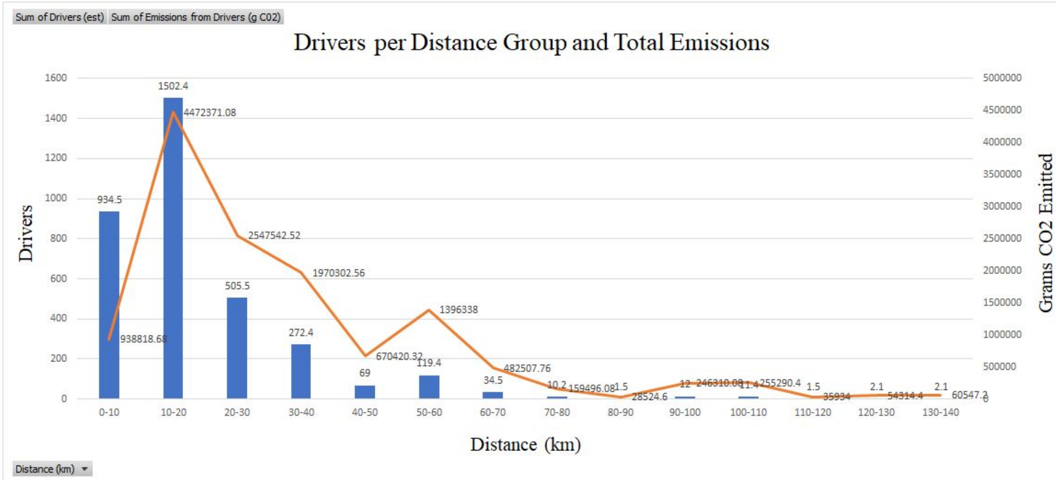


**Fig. 3:** Bar graph showing drivers per distance group and total emissions.

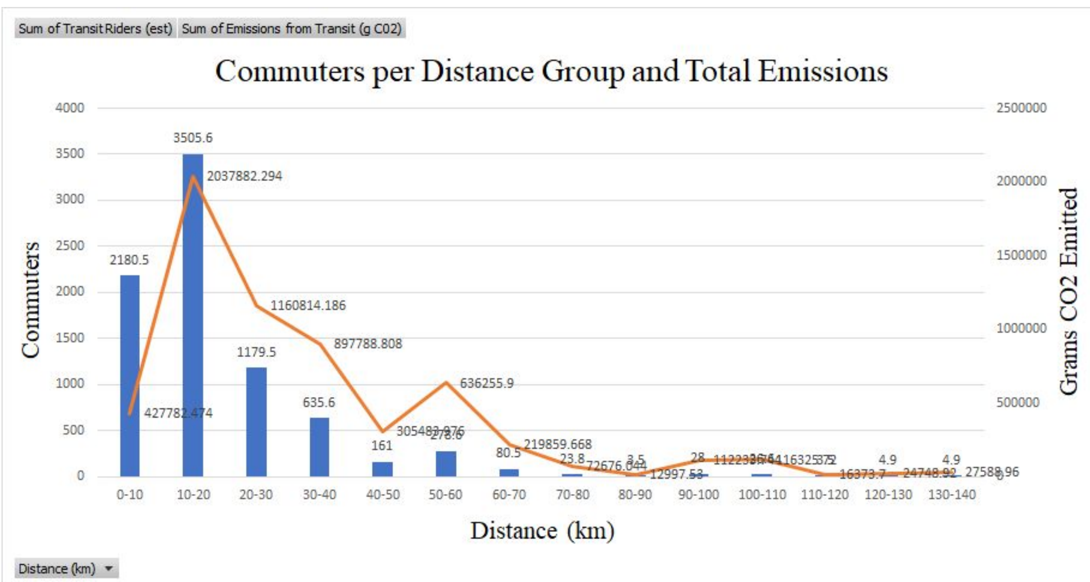


**Fig. 4:** Bar graph showing commuters per distance and their total emissions.

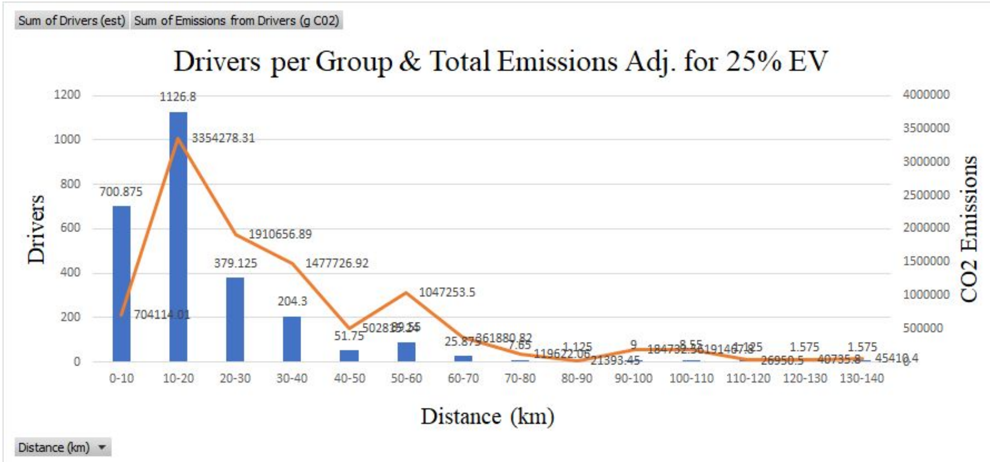


**Fig. 5:** Bar graph showing Scenario 1; drivers per distance and emissions, with an adjustment for 25% electric or green vehicles.

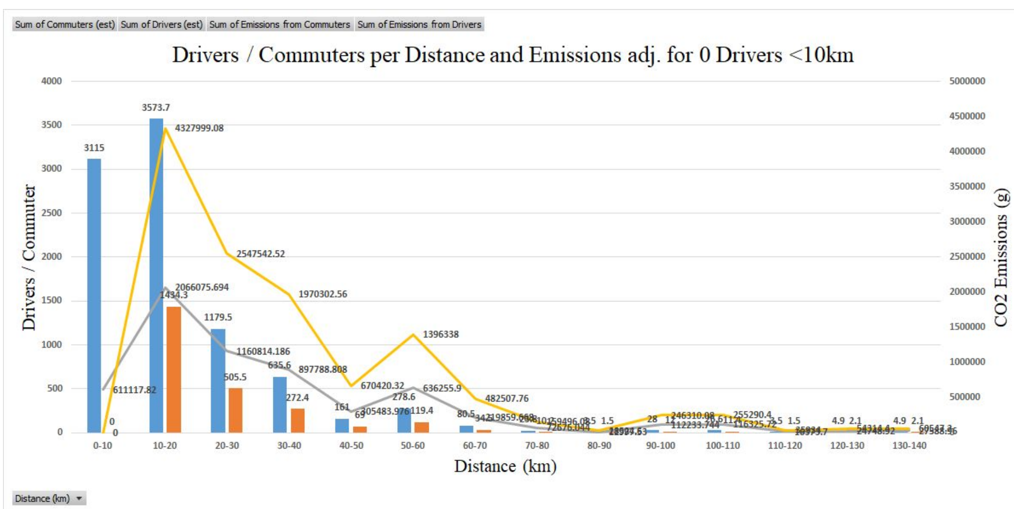


**Fig. 6:** Bar graph showing Scenario 2; drivers or commuters (less than 10km away from campus) per distance and emissions, with an emissions adjustment for 25% electric or green vehicles.

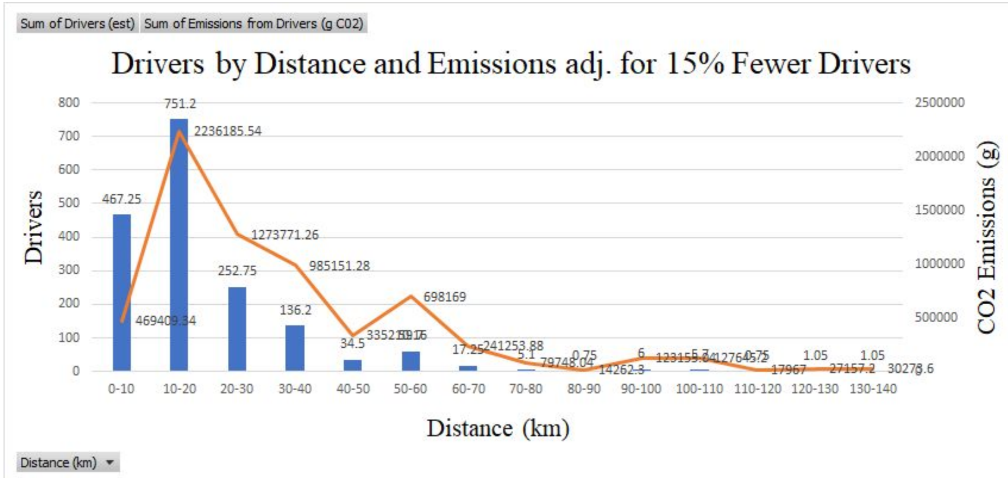


**Fig. 7:** Bar graph showing Scenario 3; drivers or commuters per distance and emissions, with an emissions adjustment for 15% fewer drivers and more commuters.

## Conclusion

This project was undertaken to create a foundation for future research and exploration into decreasing the ecological and carbon footprints of the Scarborough Campus. It was found that of 11,595 students, 3,478 drove as their primary means of travel to campus which results in the emission of 13.3 metric tonnes of $CO_2$ per day (one-way). Commuters from public transit, meanwhile, emitted some 6.1 tonnes of $CO_2$. While these emissions figures are significant, the focus of this research is the degree to which emissions can be reduced through a variety of simulated scenarios. Through three different scenarios driver based emissions were able to be reduced anywhere from 8% up to a staggering 50%. The most efficacious scenario was one in which 15% of drivers were able to make public transport their primary means of commuting, resulting in a meager 21% increase in public transport related emissions along with a 50% reduction in driver based emissions. While campus initiatives show some promise in incentivizing sustainable energy consumption (such as exclusive electric vehicle parking), the onus also falls upon the city of Toronto in making public transport more accessible and convenient for all.

## Recommendations

Going forward, our group recommends that future research conducted on the contribution of transportation to university ecological footprints should include more reliable data. As mentioned earlier in this report, time constraints and the occurrence of the COVID-19 pandemic made gathering data from our demographic of study very challenging, and we therefore had to extrapolate pre-existing information regarding campus users and parking habits. Hopefully, any individuals in the future who endeavour to seek out a better understanding of this relationship between transportation and university ecological footprints will allocate a sufficient amount of time to gather information from their target demographic. For instance, it would be beneficial for future researchers to use the survey created at the earlier stages of this project to gain a better understanding of campus users' transportation habits to and from campus and the consequential emissions of these transportation habits. With regard to policy, our group urges further investigation by both the University of Toronto, but also the municipality of Toronto into reducing these emissions. As explained earlier in this report, our group played around with a few possible scenarios for reducing these emissions. We recommend that the University of Toronto and the city of Toronto begin developing the necessary infrastructure to make transportation for the city's thousands of students less consuming of harmful fossil fuels. Doing so would improve the ecological footprints of both and contribute to the overall global goal of reducing climate change due to the reduction in greenhouse gas emissions.

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**Appendix**

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